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September 24, 2013

ULNRC-06042

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

10 CFR 50.73

Ladies and Gentlemen:

DOCKET NUMBER 50-483
CALLAWAY PLANT UNIT 1
UNION ELECTRIC CO.
FACILITY OPERATING LICENSE NPF-30
LICENSEE EVENT REPORT 2013-008-00
ARCING IN ISOPHASE BUS RESULTS IN A GENERATOR TRIP, TURBINE TRIP, REACTOR TRIP AND A SMALL FIRE

The enclosed licensee event report is submitted in accordance with 10 CFR 50.73(a)(2)(iv)(A) to report arcing in the isophase bus which resulted in a generator trip, turbine trip, and reactor trip.

If you have any questions regarding this submittal, please contact Mr. Tom Elwood at 314-225-1905.

This letter does not contain new commitments.

Sincerely,

Fadi M. Diya
Vice President Nuclear Operations

Enclosure LER 2013-008-00

cc: Mr. Marc L. Dapas
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U. S. Nuclear Regulatory Commission
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Index and send hardcopy to QA File A160.0761

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APPROVED BY OMB: NO. 3150-0104 EXPIRES: 10/31/2013

Estimated burden per response to comply with this mandatory collection request: 80 hours. Reported lessons learned are incorporated into the licensing process and fed back to industry. Send comments regarding burden estimate to the FOIA/Privacy Section (T-5 F53), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by internet e-mail to infocollects@nrc.gov, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202, (3150-0104), Office of Management and Budget, Washington, DC 20503. If a means used to impose an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

LICENSEE EVENT REPORT (LER)

(See reverse for required number of digits/characters for each block)

1. FACILITY NAME	2. DOCKET NUMBER	3. PAGE
Callaway Plant Unit 1	05000483	1 OF 10

4. TITLE

Arcing in isophase bus results in a generator trip, turbine trip, reactor trip and small fire

5. EVENT DATE			6. LER NUMBER			7. REPORT DATE			8. OTHER FACILITIES INVOLVED	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REV NO.	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
07	26	2013	2013	- 008 -	00	09	24	2013		
									FACILITY NAME	DOCKET NUMBER

9. OPERATING MODE

1

10. POWER LEVEL

100

11. THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR§: *(Check all that apply)*

☐ 20.2201(b)	☐ 20.2203(a)(3)(i)	☐ 50.73(a)(2)(i)(C)	☐ 50.73(a)(2)(vii)
☐ 20.2201(d)	☐ 20.2203(a)(3)(ii)	☐ 50.73(a)(2)(ii)(A)	☐ 50.73(a)(2)(viii)(A)
☐ 20.2203(a)(1)	☐ 20.2203(a)(4)	☐ 50.73(a)(2)(ii)(B)	☐ 50.73(a)(2)(viii)(B)
☐ 20.2203(a)(2)(i)	☐ 50.36(c)(1)(i)(A)	☐ 50.73(a)(2)(iii)	☐ 50.73(a)(2)(ix)(A)
☐ 20.2203(a)(2)(ii)	☐ 50.36(c)(1)(ii)(A)	☒ 50.73(a)(2)(iv)(A)	☐ 50.73(a)(2)(x)
☐ 20.2203(a)(2)(iii)	☐ 50.36(c)(2)	☐ 50.73(a)(2)(v)(A)	☐ 73.71(a)(4)
☐ 20.2203(a)(2)(iv)	☐ 50.46(a)(3)(ii)	☐ 50.73(a)(2)(v)(B)	☐ 73.71(a)(5)
☐ 20.2203(a)(2)(v)	☐ 50.73(a)(2)(i)(A)	☐ 50.73(a)(2)(v)(C)	☐ OTHER
☐ 20.2203(a)(2)(vi)	☐ 50.73(a)(2)(i)(B)	☐ 50.73(a)(2)(v)(D)	Specify in Abstract below or in NRC Form 366A

12. LICENSEE CONTACT FOR THIS LER

FACILITY NAME	TELEPHONE NUMBER (Include Area Code)
T.B. Elwood, Supervising Engineer, Regulatory Affairs and Licensing	314-225-1905

13. COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT

CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX
B	EL	DMP	Ruskin	Y	B	EL	IPBU	Delta Unibus	Y

14. SUPPLEMENTAL REPORT EXPECTED

☐ YES *(If yes, complete 15. EXPECTED SUBMISSION DATE)* ☒ NO

15. EXPECTED SUBMISSION DATE

MONTH	DAY	YEAR

ABSTRACT *(Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines)*

At approximately 2333 on July 26, 2013, electrical faults caused damage to the isophase bus to the unit auxiliary transformer and main generator neutral connection box. Protective relaying initiated a generator trip to isolate the faulted area and to trip the main turbine. A reactor trip from 100% power resulted from the turbine trip. A small cable insulation and oil collection pan fire initiated from the main generator neutral connection box fault and created smoke throughout the Turbine Building. An Unusual Event was declared as a result of the fire and resulting smoke.

The fire was extinguished within 30 minutes and smoke was removed from the building using installed equipment.

The electrical faults were the result of a damper blade that was loose within the isophase bus ductwork, creating arcing between the bus, damper blade, and duct. The loose damper blade is attributed to damper failure based on the determination that the operational isophase bus duct airflow rate exceeded the design flow rate for the backdraft dampers. Design and installation errors were made at the main generator neutral connection box during plant construction.

Redesigned backdraft dampers were installed, and grating was added to prevent debris from entering the isophase bus ducts. Modifications were also made to the generator neutral connection box.

1. DESCRIPTION OF STRUCTURE(S), SYSTEM(S) AND COMPONENT(S):

Note: Energy Industry Identification System component function identifiers and system names are listed at the end of the LER instead of in the text below.

The event reported in this LER was initiated by a failure in the main generator isophase bus system. The main generator isophase buses transport electrical power from the main generator to the main step-up transformers, unit auxiliary transformer, and excitation transformer. The system includes the main generator neutral connection box. The nominal system voltage is 25,000 volts rms (root mean square) phase-to-phase.

As shown in the diagram at the end of this document, this system incorporates a water-cooled, forced air cooling system to cool the bus conductors heated from the large currents flowing in the high voltage bus bars within the bus ducts. Two redundant fans, cooling coils, and associated dampers make up the cooling skid. Forced air from the fan(s) enters the "B" phase isophase duct and splits to flow toward the main generator and the main transformers. Return crossovers are located at the main generator high side connection box and at the main transformer bus work to return airflow through the "A" and "C" phase isophase ducts to the air to water heat exchangers located at the fan suctions. Back-draft dampers are located on the fan discharge.

With regard to the overall design provisions for supplying power to plant loads, power to the non-safety related portions of the plant is supplied by the Unit Auxiliary Transformer during normal plant operation with the main generator online. When the plant (generator) is offline, power to those loads is supplied from the switchyard via the Startup Transformer. In the event of a plant trip, the power supply to the non-safety related plant equipment is automatically switched to the Startup Transformer.

Per the plant's design, an auxiliary feedwater actuation is an expected response to a reactor trip.

2. INITIAL PLANT CONDITIONS:

The plant was in Mode 1 at 100 percent power when the event occurred on July 26, 2013. No Technical Specification Conditions or Required Actions were in effect at the beginning of the shift, (approximately 1900) on July 26, 2013. Approximately 14 minutes prior to the event, a monthly swap of the isophase bus cooling duct fans was performed.

Unknown at the time of the event, a blade from one of the isophase bus dampers had been previously thrown and was inside one of the isophase bus ducts.

3. EVENT DESCRIPTION:

Overview:

At 2333 hours on July 26, 2013, fourteen minutes after Operation Technicians performed the monthly periodic swap of the isophase bus cooling fans, TVMA04 and TVMA03, electrical faults caused extensive damage at the Unit Auxiliary Transformer, XMA02, "B" phase isophase feed-through bushing and at the Main Generator, MA01, neutral connection box. Protective relaying initiated a generator trip to isolate the faulted area and to trip the main turbine. A reactor trip from 100% power resulted from the turbine trip. A small cable insulation and oil collection pan fire initiated from the main generator neutral connection box fault and created smoke throughout the Turbine Building.

The plant fire brigade was dispatched, and the Shift Manager declared an Unusual Event (UE) based on Emergency Action Level HU2.1 for the fire. After review, it was determined that HU 2.1 did not apply due to location of the fire in the Turbine Building. HU3.1 for toxic gas in amounts that affect normal operation did apply. Appropriate notifications were made. Plant operators continued event response to the reactor trip and equipment actuations using emergency and operating procedures.

At 0101 hours on July 27, the Control Room Operators notified the NRC of the Unusual Event closeout.

A timeline summarizing the sequence of events for the overall event is provided below.

Timeline:

Note: Times between 2300 and 0000 are on July 26, 2013, times between 0000 and 0800 are on July 27, 2013

Time	Description
2319	Swapped Isophase Bus Duct fans from TVMA04 to TVMA03.
2333	Received first-out annunciator, "Unit Trip Turbine Trip," and all reactor control rods fully inserted. Entered the plant's emergency procedures. (Note: per plant design, an Auxiliary Feedwater Actuation is received when the plant trips.)
2333	Startup transformer transfer delayed, tripping components powered from 13.8 kv buses PA01 and PA02 (reactor coolant pumps, circulating water pumps, central chiller).
2335	Security reports smoke in the plant north end of the turbine building. Some security personnel relocated out of the turbine building. Multiple alarms received on panel fire protection panel KC008 including firewater pumps running.
2337	Fire Brigade dispatched.
2349	Unusual Event declared per EAL HU2.1: a non-hostile initiated fire in a specified area (generally, a safety-related building) which is not extinguished within 15 minutes of

Control Room notification.

2356 Initial notifications of the Unusual Event were made to the State and Counties.

0002 Fire Brigade Leader reports fire is extinguished.

0008 Started "D" reactor coolant pump to restore reactor coolant system pressure control.

0015 Notified the NRC Operations Center of the Unusual Event due to a fire not extinguished within 15 minutes of control room notification, EAL HU 2.1. The fire was located in the turbine building near the main generator. (Note: NRC Event Notification number 49219)

0018 Started "A" reactor coolant pump.

0025 Follow-up notifications sent to the State and Counties.

0036 Shift Manager had conference call with the NRC Headquarters Operation Officer and NRC Region IV Operations Center.

0037 Commenced boration of the reactor coolant system to 1200 ppm boron for shutdown margin.

0053 Second follow-up notification sent to State and Counties.

0056 The Control Room was notified of a significant leak at the Condensate Polishers and flooding of the Turbine Building basement.

0101 Notified NRC Headquarters Operations Center of the closeout of the Unusual Event.

0224 Started "A" Circulating Water Pump to restore flow through the condenser.

0225 Reset Turbine Driven Auxiliary Feedwater Actuation Signal (TDAFAS) and the Turbine Driven Auxiliary Feedwater pump (TDAFP).

0330 Notified the NRC Headquarters Operation Center (4-hour notifications) of a Reactor Protection System actuation, and offsite notifications.

0448 Started the Startup Main Feedwater Pump.

0501 Stopped both Motor-driven Auxiliary Feedwater Pumps.

0707 Notified the NRC Headquarters Operation Center (8-hour notification) of an Auxiliary Feedwater Actuation that occurred as a result of the plant trip.

0726 Contacted the NRC Operations Center to notify them of correction to the Notification of Unusual Event performed on July 26, 2013. After review, it was determined that HU 2.1 did not apply due to location of the fire in the Turbine Building. HU3.1 for toxic gas in amounts that affect normal operation did apply. (Note: This EAL is applicable due to the heavy smoke release from burning electrical insulation and melted bus and ductwork which restricted access to the turbine building area where the fire took place.)

Discussion related to the electrical faults which initiated the generator trip:

A post-event evaluation was conducted, which included development of the likely sequence-of-events that occurred and which led to the fault in the isophase bus duct and eventually caused the

generator trip and turbine trip. The following is excerpted from the report that resulted from that effort.

23:19 - Fan swap-over
Operation's technicians performed a periodic operating fan swap of the isophase bus cooler fans to equalize run times on the fans. Per procedure OTN-MA-00001, fan TVMA04 (discharges through damper MAD0007) is tripped, which results in automatic actuation of fan TVMA03 (discharges through damper MAD0006). Fan swap-over was performed per the procedure and TVMA03 was left operating.

23:33:48.638 - Initial transient
The airflow change caused by swapping the fans moved a thrown MAD0007 damper blade to a position that caused arcing in the "B" isophase bus. The dead air space where the blade was located then had turbulent airflow. The blade is suspected to have sporadically moved due to the forced airflow and caused periodic arcing and damage as it was blown down the isophase duct for 14 minutes. This last momentary arc was caught in the pre-fault data initiated by the relay protection lockout.

This arcing damaged the damper blade to the point that vaporization of the aluminum occurred, thus releasing ionized gas and metal vapor. The cloud of ionized gas and metal vapor traveled through the system and partially collected at the B-phase isophase bus connection to the unit auxiliary transformer and at the main generator neutral connection box. These locations in the system do not see full airflow.

23:33:48.94 - Secondary transient, catastrophic failure
The B-phase isophase bus again went to ground. This was most likely due to the continued movement of the arcing damper blade, resulting in additional gas cloud generation and potentially resulting in blowing an arc down the ductwork. The 'B' phase isophase bus connection to the unit auxiliary transformer and the main generator neutral (in the neutral connection box) were now faulting at the same time. At this point in the event, a grounding loop was created which bypassed the generator neutral transformer / resistor connection and resulted in a solid line-ground fault on the generator with a peak current up to 220kA. These locations faulted due to the aforementioned gas cloud generation and arc movement from the damper blade.

This high amperage resulted in a large electrical fault and blowout from the expanding vaporized aluminum and a subsequent pressure wave at both of the fault locations, as evidenced by the resultant damage at the neutral connection box and unit auxiliary transformer connection bus duct condition post-event. This pressure wave resulted in catastrophic failure of both the MAD0006 and MAD0007 backdraft dampers.

4. ASSESSMENT OF SAFETY CONSEQUENCES:

The electrical faults that occurred resulted in a turbine-generator trip and a reactor trip which had the potential to challenge systems important to nuclear safety. The reactor trip was classified as "uncomplicated" and all safety systems performed properly.

This event would be categorized among the sequences addressed in FSAR Section 15.2, "Decrease in Heat Removal by the Secondary System." Section 15.2 sequences that most closely reflect the event reported in this LER include "Loss of External Electrical Load," "Turbine Trip," and "Loss of Nonemergency AC Power to the Station Auxiliaries." All of these FSAR Section 15.2 sequences are considered to be ANS Condition II events, i.e., Faults of Moderate Frequency. Following the declaration of an Unusual Event, the On-Shift Dose Assessment Technician reported to the Control Room and verified that no radiological release above normal operating limits was occurring. There was no radiological safety impact to site personnel or to the general public as a result of this event. This event occurred with the plant operating at 100% power. The full power condition represents the limiting case for the FSAR Section 15.2 sequences listed above. Therefore, there are no alternative conditions that could be postulated that would result in more limiting consequences to the plant.

5. REPORTING REQUIREMENTS:

This LER is submitted pursuant to 10 CFR 50.73(a)(2)(iv)(A) to report a reactor protection system actuation while critical and an auxiliary feedwater system actuation.

In reviewing the event, it was determined that even though the event was reported per the plant's emergency plan, the circumstances associated with the fire did not actually require reporting per 10 CFR 50.73(a)(2)(x). That regulation requires reporting "Any event that posed an actual threat to the safety of the nuclear power plant or significantly hampered site personnel in the performance of duties necessary for the safe operation of the nuclear power plant including fires, toxic gas releases, or radioactive releases." The fire was in a part of the plant that does not contain safety-related equipment, and the fire brigade was able to extinguish the fire within a half hour and exhaust smoke from the building. While some security personnel were relocated to alternate positions from the turbine building, they were able to return to their normal posts within three hours. Additionally, security functions were able to be performed in the alternate positions. Safety-related equipment was not affected by the smoke and fire.

6. CAUSE OF THE EVENT and CORRECTIVE ACTIONS:

The cause of the reactor trip was a trip of the main turbine. Protective relaying initiated a trip of the generator output breakers to isolate the faulted area on the isophase bus and unit auxiliary transformer and to trip the main turbine. The auxiliary feedwater actuation was initiated as a result

of low steam generator water levels or tripping of both main feedwater pumps.

The electrical faults that occurred in the 'B' isophase bus duct above the Unit Auxiliary Transformer and in the Main Generator Neutral Connection Box were responsible for a turbine-generator trip and a reactor trip. As a consequence of the electrical faults, a fire broke out above the stator cooling water skid on the 2033' level of the Turbine Building.

The following presents the Causal Factors (CFs), Root Causes (RCs), Corrective Actions to Prevent Recurrence (CATPRs), and Corrective Actions (CAs) developed from the investigation:

CF 1: A latent design issue from plant construction left the isophase bus duct cooling flow rates in excess of the design rating of the isophase cooler backdraft dampers [25,000 cubic feet per minute (cfm) (design) vs. 18,000 cfm (rating) and 34,000 cfm (actual)]. The actual system flow introduced additional potential failure mechanisms to the backdraft dampers.

RC 1: The vendor provided a design in which the operational flow rate exceeded the design flow of the backdraft dampers and increased the risk of failure.

CATPR 1: A modification was implemented to install isophase cooler backdraft dampers designed for the flow rates and add grating above the isophase cooler backdraft dampers to prevent debris from entering the isophase bus ducts. This modification was installed prior to plant startup on August 18, 2013.

CF 2: Design and installation errors at the Main Generator Neutral Connection Box were made during plant construction (i.e., insufficient air gap, neutral grounding cable shield not grounded, insufficient creep distance on neutral grounding cable, deionizer filter painted, sharp corners and bolts used in neutral connection box design).

RC 2: Multiple deficiencies in the design and installation of the Main Generator Neutral Connection Box allowed an electrical fault to occur when challenged by a high voltage potential.

CATPR 2: A modification was implemented to rework the installation of Main Generator Neutral Connection Box to provide proper air gap and creep distances, proper cable shield grounding, and to eliminate sharp corners and points and remove paint on the deionizer and deionizer mounting brackets, as well as replace the neutral ground cable conduit with non-ferrous materials. The modification was installed prior to plant startup on August 18, 2013.

CF 3: In Refuel 18, an inspection found that an isophase cooler backdraft damper had failed and a blade had been ejected into the 'B' isophase bus duct. There was a failure to recognize that the inspections of the backdraft dampers instituted to close Health Risk 2005028 were not sufficient to identify degradation in time to prevent failure.

RC 3: There was failure to effectively manage risk.

1) The decision to credit inspection of the backdraft damper to mitigate the single point vulnerability of a damper blade entering the isophase bus and potentially causing a generator trip was deficient. The corrective action document response failed to recognize and correct this deficient barrier.
2) No new health issue was generated for this single point vulnerability. There was an understanding of the possible consequences of the failure of a backdraft damper blade; however, there was no escalation of the issue to drive a more robust response.
3) Risk insights were not used to escalate the significance of the corrective action document, thus missing the opportunity to evaluate and develop more robust corrective actions.

CA 3.1: Training on the process to identify, initiate, develop, and implement a health issue and its solution will be developed and implemented. The training is expected to include a discussion on identification and implementation of bridging strategies. The targeted population will likely be Systems, Component and Program engineers.

CA 3.2: The administrative procedure for the plant's corrective action program (i.e., APA-ZZ-00500 App 14, 15, and 21) will be revised to ensure after the responsible person has a full understanding of the CAR's issues, that if the issue's significance is higher than originally screened that it be returned to the CAR Screening Committee to be reassessed for proper CAR significance level.

7. PREVIOUS SIMILAR EVENTS:

Callaway has not experienced a plant trip caused by faults in the isophase bus. Callaway has had reactor trips in the past. The more recent trips were described in the LERs listed below. Additionally, an internal corrective action document was written in 2011 to report that a damper blade was ejected into the isophase bus duct.

2008-008-00 The reactor was tripped manually due to "B" condensate pump tripping due to a motor ground fault. The event date was December 14, 2008.

2008-006-00 Reactor trip due to a turbine trip during power reduction following loss of the "C" condensate pump. The event date was December 11, 2008.

8. OTHER:

Below are the Energy Industry Identification System (EIIS) component function identifiers and system names for the components and systems mentioned in the LER.

Name used in the LER	EIIS code
main generator (MA01)	System TB, Component GEN
main generator isophase bus	System EL, component IPBU
step-up transformer	System EL, Component XFMR
unit auxiliary transformer (XMA02)	System EL, Component XFMR
startup transformer	System EA, Component XFMR
main generator neutral connection box	System EL
bus bars (in the isophase bus)	System EL, Component IPBU
fans TVMMA03 and TVMA04	Component FAN
dampers	Component DMP
back-draft dampers (MAD0006 and MAD0007)	Component UDMP
auxiliary feedwater	System BA
condensate polishers	System SF
13.8 kv buses PA01 and PA02	System EA, component SWGR
reactor coolant pumps	System AB, Component P

A simplified diagram of the isophase bus system is presented on the next page.

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NARRATIVE

Simplified Diagram of the Isophase Bus System